THERMOPLASTIC FORMING METALLIC GLASS TEXTURES FROM GLASS MOLDS

CROSS-REFERENCE TO RELATED PATENT APPLICATION

[0001] This patent application claims the benefit under 35 U.S.C. § 119(e) of U.S. Patent Application Ser. No. 62/646,702, entitled "THERMOPLASTIC FORMING METALLIC GLASS TEXTURES FROM GLASS MOLDS," filed on Mar. 22, 2018, which is incorporated herein by reference in its entirety.

FIELD

[0002] The disclosure is directed to materials and methods for thermoplastic forming of metallic glass replicating the fine surface texture from a textured glass mold.

BACKGROUND

[0003] A silicate glass can have very fine surface texture after etching. Mimicking the surface structure of the silicate glass in a metallic alloy or metallic glass, however, is difficult to accomplish using conventional etching techniques. There remains a need to develop a method for achieving fine surface texture on metallic glasses or amorphous alloys.

BRIEF SUMMARY

[0004] In an embodiment, a thermoplastic forming method is provided for replicating fine texture from a silicate glass mold. The method may include placing a metallic glass in a glass mold having a portion of a surface with a fine surface texture. The method may also include heating the glass mold to a processing temperature above the glass transition temperature of the metallic glass. The method may further include applying a pressure to the silicate glass mold. The method may also include cooling the glass mold to form a metallic glass article replicating the fine surface texture from the portion of the glass mold.

[0005] In some variations, the fine surface texture of the metallic glass article varies up to 5 microns.

[0006] In some variations, the portion of the surface of the silicate glass mold is chemically etched to have the fine surface texture.

[0007] In some variations, the metallic glass comprises a material selected from a group consisting of Zr-based, Pt-based, Ni-Based, Fe-based, Ti-based, Pd-based, Au-based, Ag-based, Cu-based, Al-based, and Mo-based metallic glass.

[0008] In some variations, the processing temperature is lower than the crystallization temperature of a metallic glass.

[0009] In some variations, the article remains in an amorphous phase.

[0010] In some variations, the metallic glass has a TTT crystallization curve.

[0011] In some variations, a trajectory of the processing temperature versus time does not cross the TTT crystallization curve to void crystallization.

[0012] Additional embodiments and features are set forth in part in the description that follows, and will become apparent to those skilled in the art upon examination of the specification or may be learned by the practice of the disclosed subject matter. A further understanding of the nature and advantages of the disclosure may be realized by reference to the remaining portions of the specification and the drawings, which forms a part of this disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The description will be more fully understood with reference to the following figures and data graphs, which are presented as various embodiments of the disclosure and should not be construed as a complete recitation of the scope of the disclosure, wherein:

[0014] FIG. **1**A shows a surface topology of a textured stainless steel mold in accordance with embodiments of the disclosure.

[0015] FIG. **1**B shows the surface depth profile of FIG. **1**A in accordance with embodiments of the disclosure.

[0016] FIG. **2**A shows a surface topology of a textured silicate glass mold in accordance with embodiments of the disclosure.

[0017] FIG. **2**B shows the surface depth profile of FIG. **2**A in accordance with embodiments of the disclosure.

[0018] FIG. **3** illustrates a schematic of thermoplastic forming a metallic glass sheet into an article having a textured surface in accordance with embodiments of the disclosure.

[0019] FIG. **4** illustrates a schematic of a time-temperature-transformation (TTT) diagram for an exemplary bulk solidifying amorphous alloy in accordance with embodiments of the disclosure.

[0020] FIG. **5** is a flow chart illustrating thermoplastic forming a metallic glass with a fine texture replicating the surface texture of a silicate glass mold in accordance with embodiments of the disclosure.

[0021] FIG. **6** illustrates an image of a glass mold texture in accordance with an illustrative embodiment.

[0022] FIG. **7** illustrates a replicate texture of the glass mold of FIG. **6** for amorphous alloy $Zr_{70}Cu_{13}Ni_{9.9}Al_{3.7}Nb_{3.4}$ in accordance with an illustrative embodiment.

[0023] FIG. **8** illustrates a replicate texture of the glass mold of FIG. **6** for amorphous alloy $Zr_{67}Ti_{8.8}Ni_{9.8}Cu_{10.6}Be_{3.8}$ in accordance with an illustrative embodiment.

[0024] FIG. **9** illustrates a replicate texture of the glass mold of FIG. **6** for amorphous alloy $Pt_{57.3}Cu_{14.7}Ni_{5.3}P_{22.7}$ in accordance with an illustrative embodiment.

DETAILED DESCRIPTION

[0025] The disclosure may be understood by reference to the following detailed description, taken in conjunction with the drawings as described below. It is noted that, for purposes of illustrative clarity, certain elements in various drawings may not be drawn to scale.

[0026] The disclosure provides a method of thermoplastic forming a metallic glass replicating a surface texture from a silicate glass mold. The disclosure provides a method of using a silicate glass mold rather than a metal mold in the thermoplastic forming process. The silicate glass mold can obtain a very fine and/or uniform surface texture, for example, by chemical etching. Chemical etching of a crystalline metal alloy mold is non-uniform because of different etch rates of crystalline grains compared to the grain boundaries. Metal molds can have a surface texture after blasting that is quite different a surface texture of a silicate glass mold after chemical etching. The surface texture on the silicate glass mold is much finer than the surface texture on the metal molds, e.g. a stainless steel mold, which is